

The data shown in figure 2 can now be used to analyze the astronomical spectra. For example, the absorption band of the PAH ion ( $C_{10}H_8^+$ ) shown in figure 2 can be directly compared to the absorption spectrum of the diffuse interstellar bands. These bands, which contribute to the global interstellar extinction, were discovered 80 years ago and remain an enigma to this day.

For the first time, the absorption spectrum of large organic molecules and ions can be measured under conditions that mimic entirely the interstellar conditions.

Point of Contact: F. Salama  
(650) 604-3384  
fsalama@mail.arc.nasa.gov

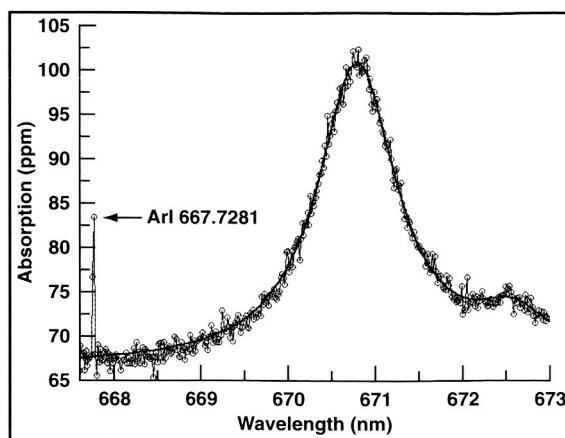


Fig. 2. The CRDS absorption spectrum of the naphthalene cation ( $C_{10}H_8^+$ ) under simulated interstellar space conditions. The spectrum is obtained when an argon free jet expansion seeded with naphthalene is exposed to a high-voltage discharge. Note the absorption line of metastable argon that is used for internal wavelength calibration.

## SPACE TECHNOLOGY

### Carbon Nanotube Deposition and Growth Technique

Lance Delzeit

Carbon nanotubes (NTs) possess electrical, mechanical, and physical properties that make them ideal for applications in nanotechnology. A major constraint to the realization of many of these applications is the ability to produce nanotubes in an industrially viable method with the characteristics desired for the given application. These characteristics include quantity, chirality, size, density, distribution, and purity of the nanotubes produced. The research described here focuses on the production of NTs with the desired density, distribution, and purity for the application to industrially viable products.

A catalyst deposition and growth technique has been developed that allows for the controlled growth of either single- or multiwalled carbon nanotubes. This technique uses ion-beam sputtering to deposit the catalyst. By changing the catalyst formula and the growth conditions, either single- or multiwalled carbon nanotubes

can be grown. Furthermore, by adjusting the conditions used to produce single-walled nanotubes, the density of the nanotubes grown can be controlled from a sparse distribution of individual single-walled nanotubes to dense mats of single-walled nanotube "ropes." "Ropes" are an association of individual nanotubes that form a larger structure—just as individual fibers make up a normal rope. The conditions for the growth of multiwalled nanotubes have been optimized for the growth of "towers." A "tower" is a structure in which the nanotubes grow in the vertical direction because of the high density of the nanotubes in that region. Each of these different structures has applications to a variety of devices.

A further advantage of this technique is the ability to pattern the catalyst onto the surface. If the application requires the nanotubes to be grown in a confined area, then the ability to restrict the deposition of the catalyst to those

areas is critical. By using this process with standard shadow-masking and lithography techniques, such patterned catalyst deposits can be created for the development of applications.

Finally, for most applications, the nanotubes need to be produced free of impurities and contamination. The two major sources of contamination in the growth of carbon nanotubes are the buildup of amorphous carbon from the extraneous decomposition of carbon feed gas and contamination by an extraneous

metal catalyst. The elimination of the extraneous metal catalyst is currently being accomplished by optimizing the catalyst formula, thus reducing the quantity of "inactive" catalyst. The removal of the amorphous carbon is being realized by the use of etching gases that preferentially remove the amorphous carbon while not damaging the carbon nanotubes.

Point of Contact: L. Delzeit  
(650) 604-0236  
ldelzeit@mail.arc.nasa.gov

## Low-Temperature Multiplexing Readouts for Airborne Astronomy

Jam Farhoomand

Cryogenic readouts are the critical electronics for infrared (IR) detector arrays and, in most instances, the dominant source of noise in an IR detection system. Various designs have been developed and perfected over years to minimize the read noise and optimize the circuitry for particular detector arrays for which the readouts are intended to be used. The present effort in this area—to develop readouts that operate at 2 kelvin and achieve improved sensitivity—is driven by the NASA charter to provide state-of-the-art IR technology to the astronomical community at large.

The simplest unit-cell design is the source follower per detector, which employs a single metal-oxide-semiconductor field-effect transistor (MOSFET) in the source follower configuration to read the detector signal. Although the simplicity of this design is attractive in terms of fabrication, minimal use of electronics real estate, and operation, it suffers from the inherent drawback that the integrated charge at the MOSFET gate debiases the detector and thereby degrades the detector linearity. In extreme cases, it can significantly diminish the detector photocurrent. Detector debiasing

could pose severe limitations for detector arrays that require low bias levels, such as those used in the far-IR. A capacitive transimpedance amplifier (CTIA) is one possible solution. This design uses a transistor in an amplifier mode and includes a capacitor in the feedback loop. The feedback capacitor serves as the integrator and, by virtue of the negative feedback, pins the detector node to a constant voltage.

The first generation of CTIA readouts, CRC-696, was manufactured by Hughes/Santa Barbara Research Center for the multiband infrared photometer (MIPS) for the Space Infrared Telescope Facility (SIRTF) instrument. This device was a 1 x 32, single-gain, DC-coupled multiplexer, optimized for low photocurrents. A few of these devices, with and without IR detectors, were tested in the lab at Ames. The success of the CRC-696 led to the development of the next generation of these devices—the SB-190—with added features to expand and enhance their performance. The SB-190 is a 1 x 32, multigain, AC-coupled CTIA designed to accommodate a broad range of IR flux (including photocurrent levels